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Research Note

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN UTAH

USDA Forest Service
Research Note INT-99 1969

USE OF SARAN SHADE CLOTH IN GREENHOUSE TO IMPROVE SUMMER SEEDLING GROWTH OF FIVE MOUNTAIN RANGE GRASSES AND FORBS

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ABSTRACT

Seedlings of five range grasses and forbs--(Agastache urticifolia (Benth.) Kuntze), (Agropyron intermedium (Host) Beauv.), (Aquilegia caerulea), (Bromus inermis Leyss.), and (Rudbeckia occidentalis Nutt.)--were grown under experimental shade conditions in a greenhouse (located in Logan, Utah) during the summer. The seedlings were either unshaded or were under densities of 6, 20, 30, or 40 percent shade provided by saran shade cloth. Best growth generally was obtained by exposure to 6 percent shade, except for Aquilegia which responded more favorably at 20 percent shade; therefore, greenhouse shading of these densities is recommended for summer use to obtain satisfactory growth of these range plants, or those with similar shade requirements.

INTRODUCTION

Summer growth of plants in the greenhouse often is poor because of the excessive heating and desiccating effects of direct solar radiation. Although they aid in holding down leaf temperatures, the use of ventilating fans and water-cooled air conditioning systems is not entirely adequate for control of the excessive heating and desiccating effects that occur in a greenhouse during the warmer days of summer. In addition to fans and air conditioning, some type of artificial shading generally is a necessity for best growth of experimental plants under these conditions.

The older method of using whitewash or similar material on the outside glass of the greenhouse is sometimes unsatisfactory due to nonuniformity of application and the denseness of shading. Also, whitewash continues to provide shade during the fall and winter when shade may be detrimental to the growth of plants. A more desirable shading material would offer a choice of densities that are uniform in application and easily reproducible; furthermore, accessory equipment should be available to make the placement onto and removal from the greenhouse a quick and simple procedure. These desirable characteristics

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can be readily obtained by use of Lumite[2] saran shade cloth (1). The cloth is a durable fabric woven from polyvinylidene chloride. A range of shades is provided by varying types and tightness of weaves.

There is information available concerning the use of saran shade cloth for optimum shading of certain horticultural species--ornamental trees, shrubs, and herbaceous flowering plants (1); however, such information is not available for species of the mountain rangeland. Therefore, experiments were directed toward providing such greenhouse shade information and determining if some degree of shade benefits the summer growth of mountain range plants under representative greenhouse conditions. The seedlings of five mountain range species were studied to determine their growth responses to four degrees of shade. It has been established that different species may vary greatly as to their shade requirements and shade tolerance (2,5); thus, no exact predictions can be made regarding the response of a particular species to any one degree of shade without experimental verification.

The seedling stage generally is considered to be more sensitive to heating and desiccating effects than are the later stages of development (4). Therefore, shade conditions suitable for the more critical seedling stage were assumed to be suitable for the mature plants.

METHODS AND MATERIALS

Seedlings of the five species (Agastache urticifolia (Benth.) Kuntze), (Agropyron intermedium (Host) Beauv.), (Aquilegia caerulea), (Bromus inermis Leyss.), and (Rudbeckia occidentalis Nutt.) were grown in the greenhouse in the unshaded condition and under Lumite shade cloth (Chicopee Mfg. Co.) with densities that provide 6, 20, 30, or 40 percent shade, i.e., reduce the total solar irradiance by these percentages. Seeds of the grasses were obtained from a commercial source and seeds of forbs were gathered from aspen rangeland in northern Utah. Seeds were planted at depths ranging from 1/4 to 1/2 inch in loam soil held in 5-pint plastic containers. Shading treatments were begun as soon as the seedlings emerged from the soil; then, within two weeks seedlings were thinned to four uniform plants per container.

Growth of the plants was evaluated by recording the weights of individual shoots that had been dried in an oven at 180°F. for 24 hours. These weight measurements were made after the seedling growth that occurred during the two-month period of July-August, 1968.

The experimental shading material consisted of 3- by 4-foot pieces of saran shade cloth which were positioned on horizontal wire supports at a height of 2-1/2 feet above the surface of the benches; there was no overlap of shading material. The arrangement of shading and plant containers was such that no direct solar radiation was received between 10 a.m. and 3 p.m. on any plants except those purposely exposed to full sunlight as a part of the experiment. During other daylight hours, plants under all treatments received the unobstructed oblique rays from the sun. At these times however, the total irradiance was low compared to mid-day conditions. Shading treatments were randomized on each of three benches, and there were two containers of seedlings of each species, for each shade density, and for each bench location. Containers within a given shading density and in a given location were rotated systematically twice weekly during the experiment. Plants received normal greenhouse care except for the experimental shading and were checked at regular intervals during the experiment for survival and signs of abnormal growth. Analyses of variance and studentized range tests (3) were used to evaluate the significance of differences in growth at the 5-percent level.

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[2]The use of trade names herein is for identification only and does not necessarily imply endorsement by the USDA Forest Service.

The experiment was conducted in a Lord and Burnham "Blue Ribbon Century" greenhouse, equipped with ventilating fans and a water-cooled air conditioning system. The cooling system is a water-curtain type in which the water trickles through a mat of fibers. This mat is 18 feet in total length (in two sections--see figure 1), 4 feet high, and 1 inch thick. Air temperature and humidity within the greenhouse were recorded on a hygrothermograph, solar irradiance with a Belfort pyrheliograph, and velocity of air movement at a height of 6 inches above the benches with a Hastings air-meter. The accuracy of the manufacturer's percentage shade designations for each density of saran shade cloth was confirmed by measuring the solar irradiance under the unshaded and each of the shaded conditions with a Kettering radiometer.

In the greenhouse, three 5- by 14-foot benches were oriented with their longer dimensions paralleling a north-south line (figure 1). The air conditioning system and three 18-inch fans were located on the east and west walls respectively, and were in operation during the day when air temperatures exceeded 70° F. The longitudinal center line of bench number 1 was located approximately 8-1/2 feet from the cooling system on the east wall. Bench number 3 was located a similar distance from the west wall. The center bench (number 2) was separated from the adjacent benches by walkways that were 2-1/2 feet in width.

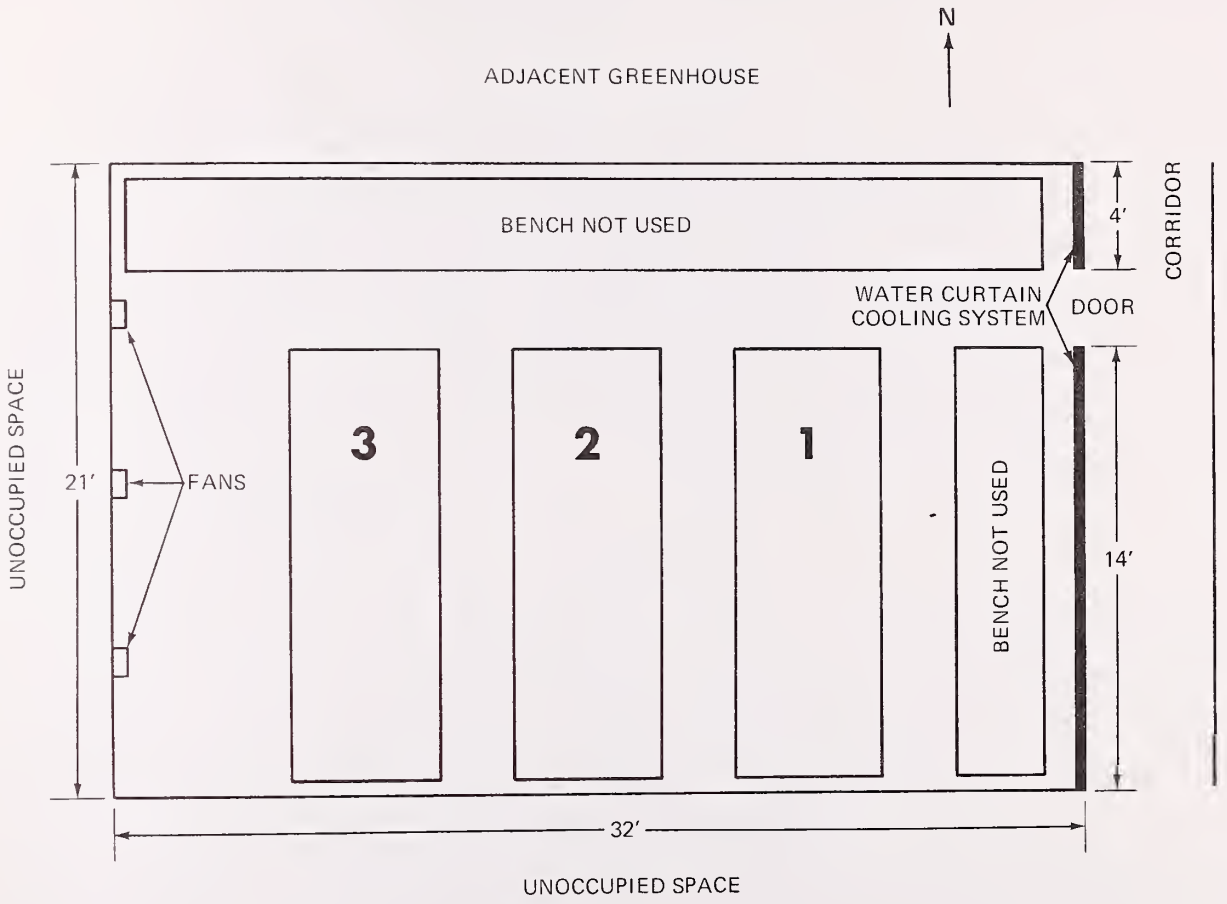

Figure 1.--Greenhouse plan showing the three benches (1, 2, and 3) upon which the experimental plants were grown.

RESULTS

By the end of the first five weeks of plant growth, mortality or abnormalities appeared in Aquilegia, Agastache, and Rudbeckia under particular treatments. Survival of Aquilegia was low in the unshaded condition. Furthermore, Agastache and Rudbeckia showed leaf burns around the margins and at the tips of the leaves in the unshaded condition, and there was evidence of chlorosis in Rudbeckia that was exposed to 40 percent shade.

The mean dry weight of shoots differed significantly in relation to the different densities of shade treatments (table 1) and bench location (table 2). Six percent of shade resulted in significantly better growth in Agastache and Agropyron; 20 percent shade was optimal for Aquilegia (table 1). For the remaining two species, the greater growth obtained at 6 percent shade failed to reach a significant level as compared to 0 and 20 percent for Bromus and 20 percent for Rudbeckia. No advantage was indicated by the light shading of Bromus although such light shade was not detrimental to growth. Shade at 6 percent and 20 percent was best for Rudbeckia.

Because only five of 24 seedlings of Aquilegia survived without shade, these data were not considered in the "0" percent shade analysis (table 1).

During the experiment, air temperatures in the greenhouse ranged from 94° to 61° F. (day and night), and relative humidities ranged from 32 to 78 percent. Solar irradiance on the predominantly clear days reached a maximum of 1.24 cal. $cm.^{-2}$ $min.^{-1}$. Air movement resulting from the fans ranged from less than 0.05 to 0.3 m.p.h. in different locations on the benches at seedling height. The greenhouse structure cast variable amounts of shade, depending upon time of day and location of the benches. These variations in air movement and shading may have been influential in the significant effect of bench location on growth (table 2).

Table 1.--Mean dry weight of shoots in mg. after two months of growth under the five shading treatments. Dry weights for each shading treatment are averaged over three benches.

Species	Shade (%)				
	0	6	20	30	40
Agastache	[1] 277^{a}	323^{b}	248^{ac}	253^{ac}	230^{c}
Agropyron	176^{a}	223^{b}	171^{a}	124^{c}	115^{c}
Aquilegia	[2] --	106^{a}	143^{b}	103^{a}	107^{a}
Bromus	210^{ab}	231^{a}	222^{ab}	193^{bc}	162^{c}
Rudbeckia	211^{a}	294^{b}	268^{bc}	239^{ac}	187^{a}

[1]Dry-weight values for any species having the same letter in superscript do not differ significantly at the 5-percent level.

[2]Data not included in analysis.

Table 2.--Mean dry weight of shoots in mg. following two months of growth at different bench locations. Dry weights for each bench are averaged over the shading treatments of table 1.

Species	Bench		
	1	2	3
Agastache	(1)258[a]	310[b]	231[c]
Agropyron	166[ab]	146[a]	174[b]
Aquilegia	98[a]	114[ab]	132[b]
Bromus	218[a]	231[a]	162[b]
Rudbeckia	244[a]	223[b]	253[a]

(1)Dry-weight values for any species having the same letter in superscript do not differ significantly at the 5-percent level.

DISCUSSION AND CONCLUSIONS

Light shading generally was advantageous for growth (table 1). For four of the species investigated, 6 percent shade appears to be a suitable compromise for use in Logan, Utah, and other localities where summer heat in the greenhouse adversely influences plant growth.

Aquilegia grew better when exposed to 20 percent shade. Undoubtedly, when studies require the growth of a number of species, special provisions will be necessary for those with specialized shade requirements; additional shade will be required over particular benches or portions of benches that hold species with greater shade requirements.

Bench location exerted an easily detectable effect on growth of seedlings otherwise shaded to the same degrees (table 2). This effect is attributable to a number of uncontrolled factors, including varying structural shading which was an unavoidable characteristic of the greenhouse structure and rate of air movement from place to place. The influence of bench location on growth should be considered in the planning of any greenhouse study.

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